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ORIGINAL ARTICLE

MRI in assessment of sports related knee injuries

Waleed Hetta *, Gamal Niazi

Radiodiagnosis Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt

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KEYWORDS

Knee injuries;
Knee MRI;
Meniscal injuries

Abstract *Purpose:* To investigate the accuracy of MRI in assessment of sports related knee injuries.
Materials and methods: From August 2012 to March 2013 thirty patients referred for sports related knee pain have been included in this study. Patients were subjected to a dedicated MR knee study and correlated knee arthroscopy and surgery.
Results: The study included thirty patients complaining of sports related knee pain, only 5 patients (16.6%) were with normal MRI findings and 25 patients (83.4%) were with abnormal MRI findings. Among the 25 patients who had injuries of their knees, 15 patients (60%) had ACL injuries, 2 patients (8%) had PCL injuries, 10 patients (40%) had meniscal injuries, 8 patients (32%) had collateral ligament injuries, 5 patients (20%) had bone injuries and 2 patients (8%) had muscular injuries. Only 7 patients (28%) were represented with isolated injury and 18 patients (72%) were represented with combined injuries. In correlation with arthroscopies and surgeries, morphological analysis was true-positive in 23 (92%) patients of the 25 injured patients, and true-negative in 3 (60%) patients of the 5 normal patients. Morphological analysis revealed overall 92% sensitivity and 60% specificity. Regarding the 15 patients who had ACL injuries, 13 patients (86.6%) were true-positive and 8 patients (80%) of the 10 patients who had meniscal injuries were true-positive.
Conclusion: MRI represents the optimal imaging tool in the evaluation of the sports related knee injuries, which has been shown to be an accurate and non invasive method of diagnosing ligament, meniscal, cartilage and muscular knee injuries.

1. Introduction:

The knee is a major weight bearing joint that provides mobility and stability during physical activity as well as balance while standing (1). Traumatic knee injuries are frequently encountered both in general practice and in the hospital setting. These injuries are often caused by sports activities and may lead to severe pain and disability (2). Magnetic resonance imaging (MRI), with its multi-planar capabilities and excellent soft-tissue contrast, has established itself as the leading modality for noninvasive evaluation of the sports knee injuries (3). Magnetic resonance imaging is a well-accepted imaging modality in the diagnostic workup of patients with knee complaints and has largely replaced diagnostic arthroscopy for this purpose (4). It is regarded as the top imaging and diagnostic tool for

* Corresponding author. Tel.: +20 1222318866.
E-mail address: waleed_hetta@yahoo.com (W. Hetta).
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the knee joint as a result of its ability to evaluate a wide range of anatomy and pathology varying from ligamentous injuries to articular cartilage lesions. Imaging of the knee requires excellent contrast, high resolution and the ability to visualize very small structures, all of which can be provided by MR imaging. The development of advanced diagnostic MR imaging tools for the joints is of increased clinical importance as it has been recently shown that musculoskeletal imaging is a rapidly growing field in MR imaging applications (5).

Arthroscopy is considered "the gold standard" for the diagnosis of traumatic intra-articular knee injuries. However, arthroscopy is an invasive procedure that requires hospitalization and anesthesia, thus presenting all the potential complications of a surgical procedure. Since its introduction in the 1980s, MRI has gained in popularity as a diagnostic tool for knee injuries. Many surgeons believe that MRI is an accurate, non-invasive method to diagnose knee injuries, and gives sufficient information to support decisions for conservative treatment and save the patient from unnecessary arthroscopy (6).

2. Patients and methods

From August 2012 to March 2013 thirty patients have been included in this study, the age of the patients ranged between 15 and 30 years with a mean age of [21.4 ± 3.45] (Table 1 and Fig. 1), regarding sex distribution, 28 patients (93.4%) were males, while 2 patients (6.6%) were females (Table 2 and Fig. 2). Patients were subjected to a dedicated MR knee study and correlated knee arthroscopy and surgery.

All patients in this study were examined using a 1.5-T MR and dedicated knee coil with sequences as follow: Sagittal PDW (SPIR).

- Sagittal T2W.
- Coronal PDW (SPAIR).
- Coronal T1W.

Table 1 Distribution of patients according to age.

Age	Patients No.	%
15–19	6	20
20–24	19	63.3
25–30	5	16.7
Total	30	100.0

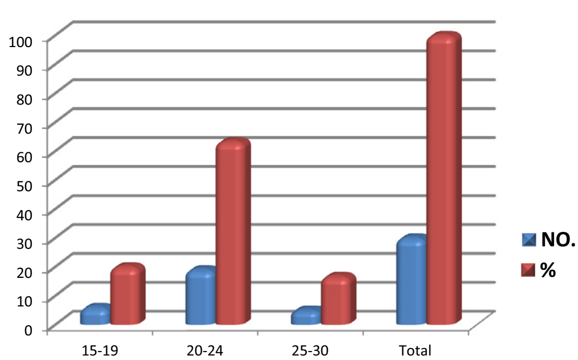

Fig. 1 Distribution of patients according to age.

Table 2 Distribution of patients according to sex.

Sex	No.	%
Male	28	93.4
Female	2	6.6
Total	30	100.0

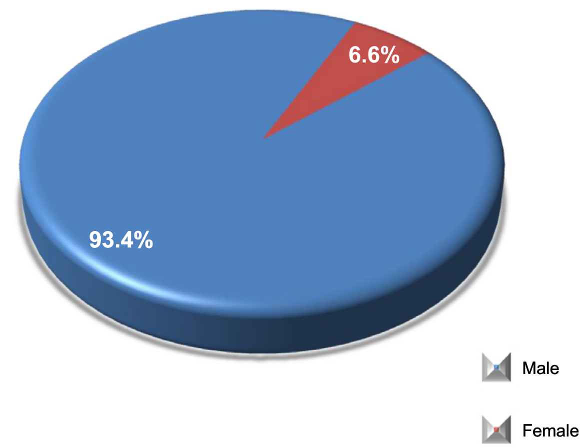

Fig. 2 Distribution of patients according to sex.

- Axial PDW (SPIR).
- Axial T1W.

2.1. Inclusion criteria

Patients with history of sports injuries.

2.2. Exclusion criteria

Post-operative cases and patients with no history of sports injuries.

The results of the MRI were compared to the knee arthroscopy and/or surgery done to the patient later on and the analysis for the data was done using SPSS program version 16 results; description of quantitative variables as mean, SD and range, description of qualitative variables as number and percentage

- Sensitivity = true positive/true positive + false negative = ability of the test to detect positive cases.
- Specificity = true negative/true negative + false positive = ability of the test to exclude negative cases.
- PPV (positive predictive value) = true positive/true positive + false positive = % of true positive cases to all positive.
- NPV = true negative/true negative + false negative = % of the true negative to all negative cases.
- Accuracy = true positive + true negative/total.

3. Results

The study included thirty patients complaining of sports related knee pain, only 5 patients (16.6%) were with normal MRI findings and 25 patients (83.4%) were with abnormal MRI findings (Table 3 and Fig. 3).

Among the 25 patients who had injuries of their knees, 15 patients (60%) had ACL injuries (Figs. 8, 9 and 13), 2 patients (8%) had PCL injuries (Figs. 18 and 19), 10 patients (40%) had meniscal injuries (Figs. 11, 12 and 14–16), 8 patients (32%) had collateral ligament injuries (Figs. 21 and 22), 5 patients (20%) had bone injuries (Fig. 10) and 2 patients (8%) had muscular injuries (Fig. 23) (Table 4 and Fig. 4).

Only 7 patients (28%) were represented with isolated injury and 18 patients (72%) were represented with combined injuries (Table 5 and Fig. 5).

The leading sports of knee injuries were football, basketball, jogging, judo and boxing, the distribution of patients according to leading sports is represented in Table 6 and Fig. 6.

In correlation with arthroscopies and surgeries, morphological analysis was true-positive in 23 (92%) patients of the 25 injured patients, and true-negative in 3 (60%) patients of the

Table 3 Distribution of patients according to MRI findings.

	Patients No.	%
Normal MRI findings	5	16.6
Abnormal MRI findings	25	83.4
Total	30	100.0

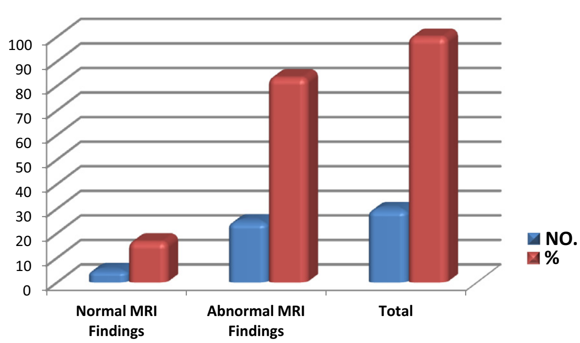

Fig. 3 Distribution of patients according to MRI findings.

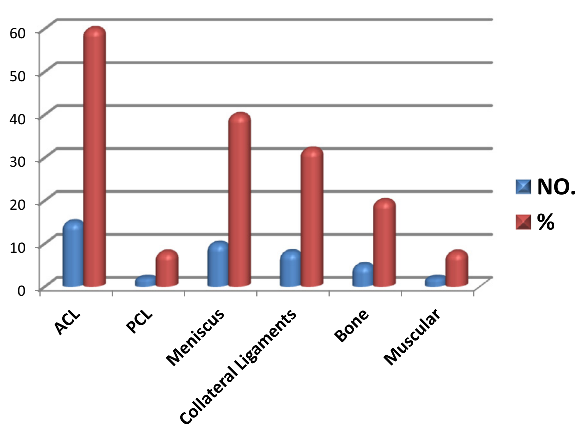

Fig. 4 Distribution of patients according to knee injuries.

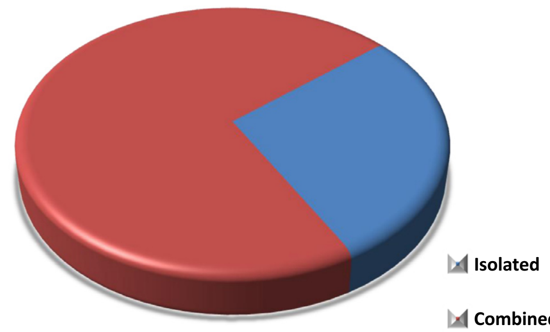

Fig. 5 Distribution of patients according to type of injury.

5 normal patients. Morphological analysis revealed overall 92% sensitivity and 60% specificity (Table 7).

Regarding the 15 patients who had ACL injuries, 13 patients (86.6%) were true-positive and 8 patients (80%) of the 10 patients who had meniscal injuries were true-positive (Table 8).

4. Discussion

MRI of the knee has become a reliable tool in the detection of knee injuries. Injuries to menisci and cruciate ligaments can be diagnosed on MRI with a high degree of sensitivity and specificity, but accuracy of MRI decreases in patients with multiple injuries (7).

Although arthroscopy has been considered the Gold Standard in diagnosis of meniscal and ligament injuries, MRI remains a reliable, non-invasive modality, which can reduce the use of diagnostic arthroscopy.

Zairul-Nizam et al. studied patients with knee injuries and concluded that the MRI is very sensitive in diagnosing meniscus and ligamentous injuries (8).

Nikolaou et al. studied 46 patients and concluded that the diagnostic power of MRI in knee injuries was substantially more than physical examinations (6).

However, in other studies there were contradictory findings, Mad husudhan et al. in the UK studied 109 injured knees. In their study the physical examinations, with the exception of meniscus tears, were superior to MRI results (9).

In a study in Mashhad on 92 patients with knee injuries, Mazlomy et al. noted similar results and reported a high accuracy for clinical examinations (10).

Behairy et al. is an Egyptian study of 70 patients that noted high diagnostic accuracy of both physical examination and MRI, and in most cases, only slight differences existed between the two methods, which was also confirmed in a study by Thomas et al. (11,12).

Major causes for the differences in the results were related to different skill levels of personnel involved in MRI interpretation, arthroscopy and clinical examination. The difference in technique used for the MRI is of importance. Studies have shown that if the examination is performed by a skilled technician, the results will be accurate (13).

However, in our study, MRI showed that the sensitivity of meniscal MRI is 80% with false positive results in 2 patients (20%) of the meniscal injuries and these results demonstrate a sensitivity less than Kuikka et al. and Ramnath et al. which reported sensitivity of MRI of 91.7% (14,15).

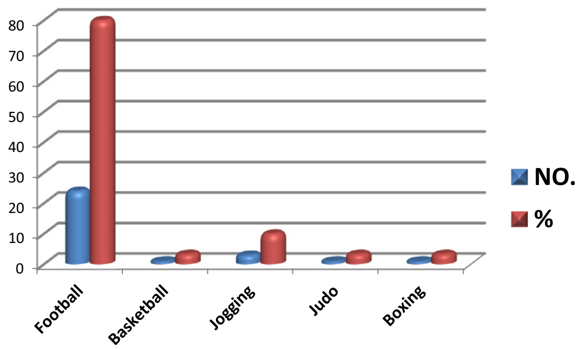

Fig. 6 Distribution of patients according to leading sports.

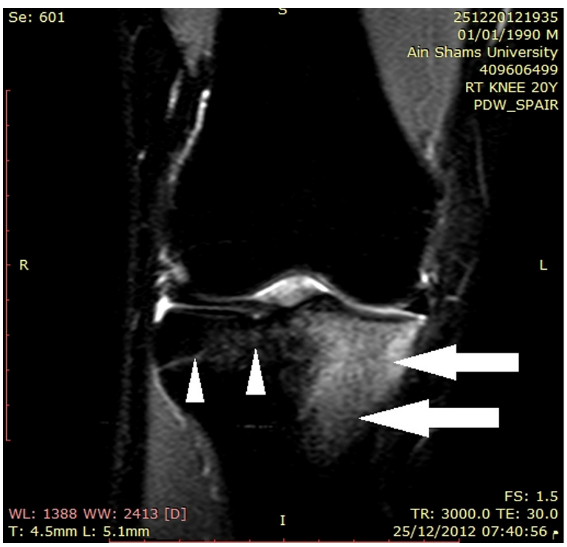

Fig. 7 Coronal PDW-SPAIR knee MR image demonstrating medial tibial plateau bone marrow contusion, exhibits high signal intensity (arrows), with underlying medial tibial plateau transverse fissure fracture (arrows heads).

Fig. 8 Sagittal T1W knee MR image demonstrating ACL partial tear. The ACL ligament is seen thickened, fuzzy with abnormal high signal intensity seen inside (arrows).

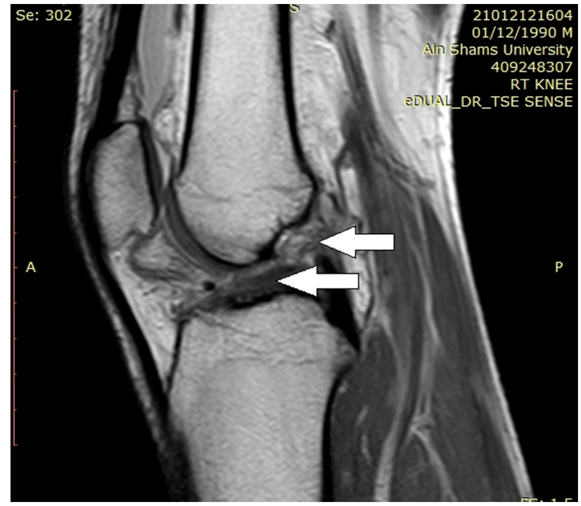

Fig. 9 Sagittal PDW knee MR image demonstrating a complete tear of the ACL with surrounding adhesions (arrows).

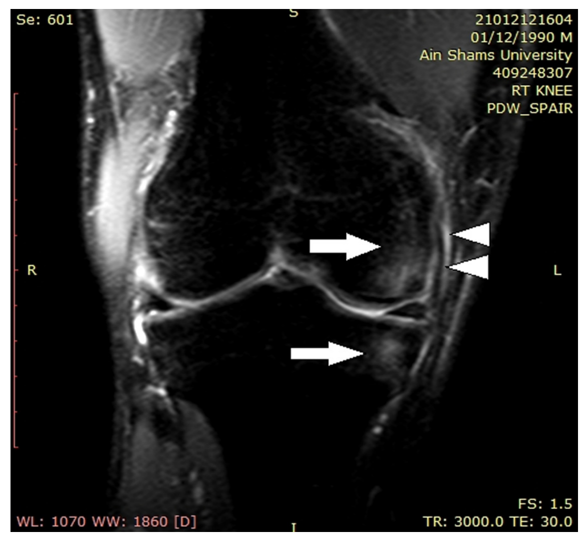

Fig. 10 Coronal PDW-SPAIR knee MR image demonstrating MCL sprain (arrows heads) as high signal intensity around the ligament. Bone marrow edema/contusion is seen affecting opposing sides of medial femoral condyle and medial tibial plateau (arrows).

There are several explanations for the misleading results of MRI regarding the menisci. Mackenzie et al. summarized the four most common reasons for false positive diagnosis; wrong diagnosis due to variable anatomic structures, overestimation of pathology countered as meniscus tear (for example chondral injuries that mimic meniscus tears), false negative arthroscopic findings and tears within the meniscus without expansion to the articular surface (16).

Jee et al. concluded that MRI in the presence of ACL tears has lower sensitivity for detecting meniscal tears due to missed lateral meniscal tear, and this may represent one of the causes of the misinterpretation of meniscal injures in this study (17).

Specificity of meniscal MRI in this study is 85% which agrees with the study of Kuikka et al. and Ramnath et al. which reported 87.1% specificity for meniscal MRI (14,15).

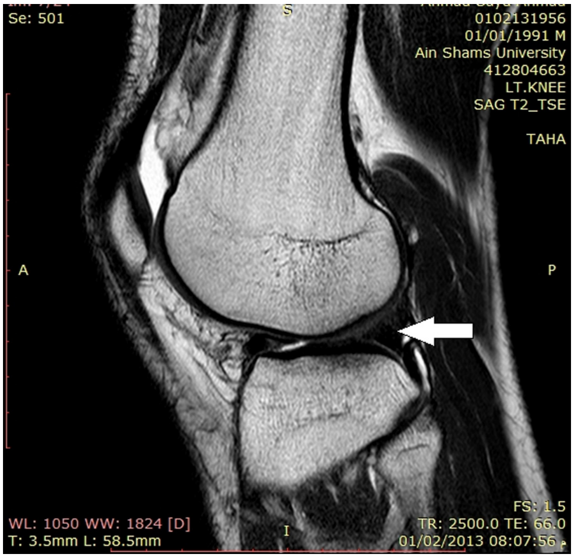

Fig. 11 Sagittal T2W knee MR image demonstrating the posterior displacement of the torn lateral meniscus (arrow).

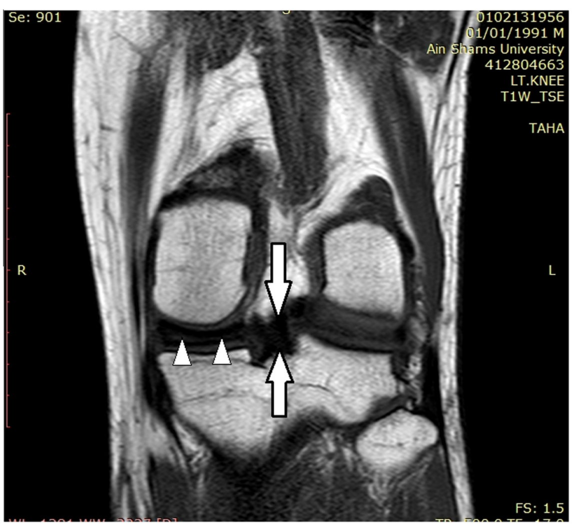

Fig. 12 Coronal T1W knee MR image demonstrating the medial displacement of the torn lateral meniscus (arrows). Posterior horn of the medial meniscus shows global degenerative intermediate signal intensity within, not reaching the articular surface (arrows heads).

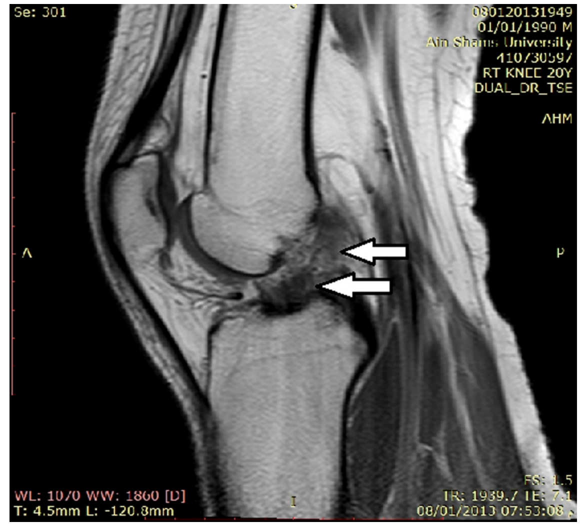

Fig. 13 Sagittal T2W knee MR image, the ACL is edematous with a fuzzy, cloudy pattern and heterogeneous signal intensity, denoting partial thickness tear (arrows).

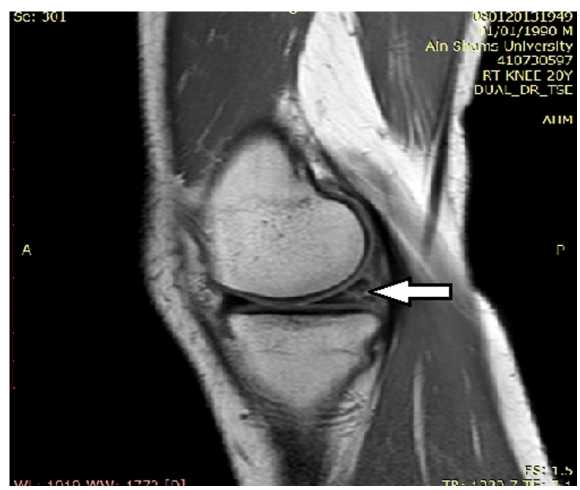

Fig. 14 Sagittal T2W knee MR image demonstrating intra meniscal bright linear signal intensity of the posterior horn of medial meniscus reaching the superior and inferior articular surfaces (arrow) denoting post traumatic tears.

The sensitivity and specificity of ACL MRI in this study were 86.6% and 90%, respectively, which agree with Khandha et al. as they observed in their study sensitivity and specificity for ACL MRI of 86.67% and 91.43%, respectively (18).

Rayan et al. presented similar results, as they report 81% sensitivity of the ACL MRI (19).

Regarding the PCL, Witonski and Vaz et al. reported that both the sensitivity and specificity of MRI in making the diagnosis of PCL tears are 100% (20,21).

In our study we evaluated only 2 PCL injuries and all were identified by MRI with 100% sensitivity and specificity, even though our results agree with Witonski and Vaz et al. studies, the number of cases is too small for statistical significant conclusions (20,21).

Some authors reported that specific imaging sequences improve the sensitivity and specificity for detecting meniscal and ligamentous tears (22).

The value of our work is that we studied the accuracy of MRI and its agreement with arthroscopy and surgery as it is actually done without using a specific imaging protocol.

Despite the fact that this study has a limitation due to small number of patients, we believe it could become a baseline and give guidance for further studies.

In conclusion, MRI is non invasive and accurate and so is superior to the diagnostic arthroscopy and we recommend MRI as the primary diagnostic tool for the evaluation of sports knee injuries.

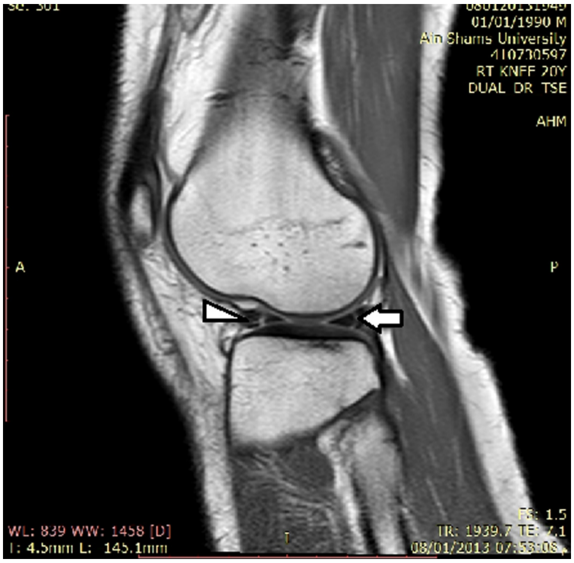

Fig. 15 Sagittal T2W knee MR image demonstrating intra meniscal bright linear signal intensity reaching the superior and inferior articular surfaces of the anterior horn lateral meniscus (arrow head) and posterior horn lateral meniscus (arrow) denoting post traumatic tears.

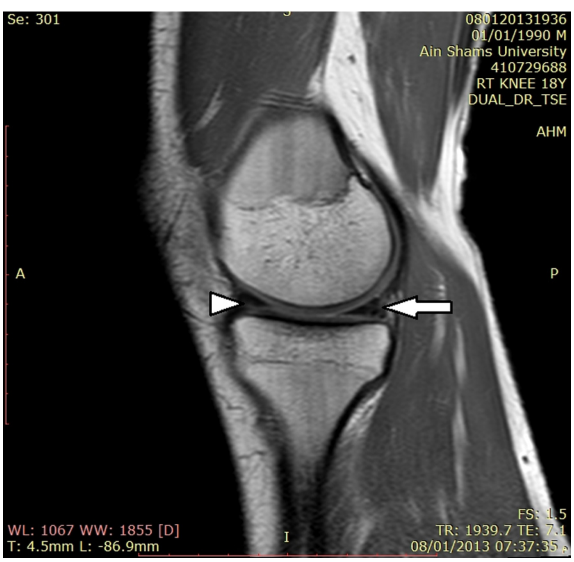

Fig. 16 Sagittal T2W knee MR image, AHMM shows linear signal alteration disrupting the inferior articular surface suggesting post traumatic tear (arrow head). PHMM shows irregular signal abnormality disrupting superior, inferior and capsular surfaces (arrow).

5. Cases

5.1. Case No. 1 (ACL partial tear and tibial plateau fracture)

A 20 years old male patient presented with right knee pain and swelling for 2 weeks duration after direct trauma during football game (Figs. 7 and 8).

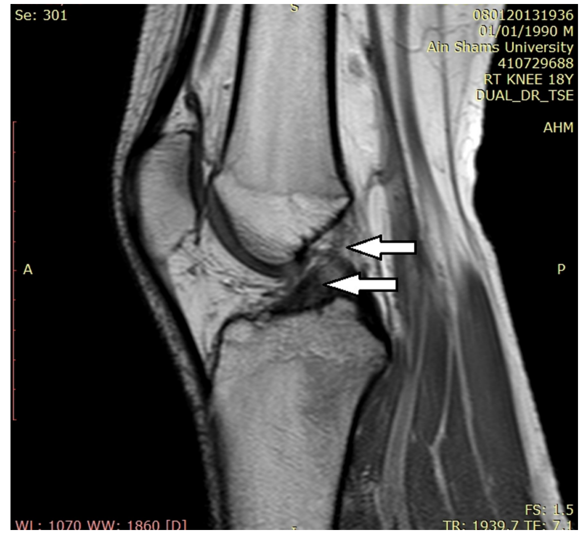

Fig. 17 Sagittal T2W knee MR image, ACL is diffusely thickened with intermediate signal within its fibers suggesting its sprain (arrows).

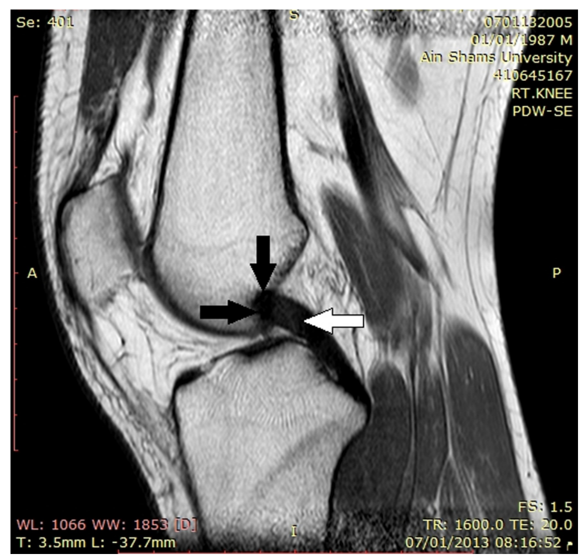

Fig. 18 Sagittal PDW knee MR image demonstrating PCL Sprain as the PCL is seen thickened at its femoral attachment (black arrows), with abnormal high signal intensity seen inside the ligament (white arrow), with intact fibers denoting its sprain.

5.2. Case No. 2 (ACL tear, MCL sprain and bone marrow contusion)

A 18 years old male patient presented with pain and swelling on his right knee during deep flexion (squatting and kneeling).The condition started as direct trauma on his knee while he was playing Football (Figs. 9 and 10).

5.3. Case No. 3 (bucket handle tear of lateral meniscus)

A 21 years old male patient presented with pain, clicking and locking on his left knee. The condition started as twisting after

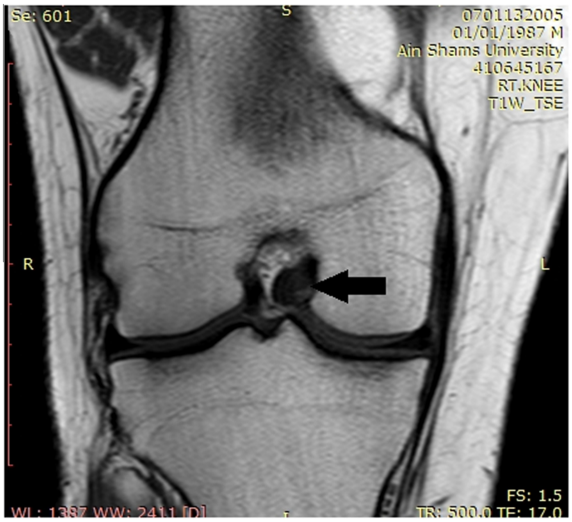

Fig. 19 Coronal T1W knee MR Image demonstrating the high signal intensity inside the PCL (arrow).

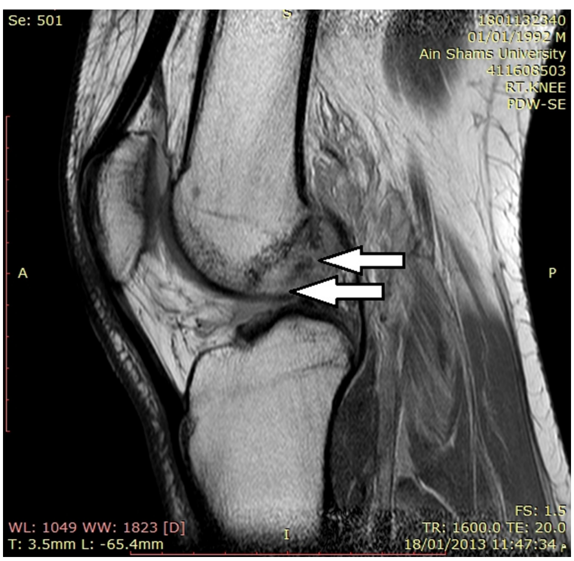

Fig. 20 Sagittal PDW knee MR image demonstrating complete tear of ACL fibers with no surrounding soft tissue edema suggesting chronic tear (arrows).

wrong jumping on his knee while he was playing Basketball (Figs. 11 and 12).

5.4. Case No. 4 (ACL tear and meniscal tear)

A 20 years old male presented with history of trauma to the right knee of 4 months duration on a football game, now the patient is presenting with pain (Figs. 13–15).

5.5. Case No. 5 (medial meniscal tear and ACL sprain)

A 18 years old male presented with history of direct trauma to the right knee of 1 month duration while he was playing Football, now the patient is presenting with pain (Figs. 16 and 17).

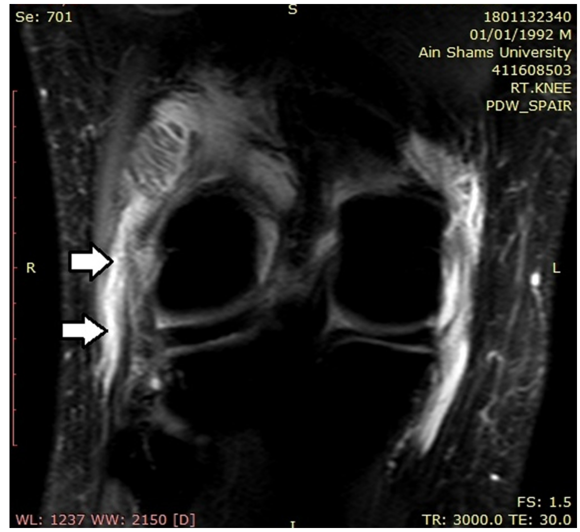

Fig. 21 Sagittal PDW (SPAIR) knee MR image, LCL shows faint bright signal suggesting its sprain (arrows).

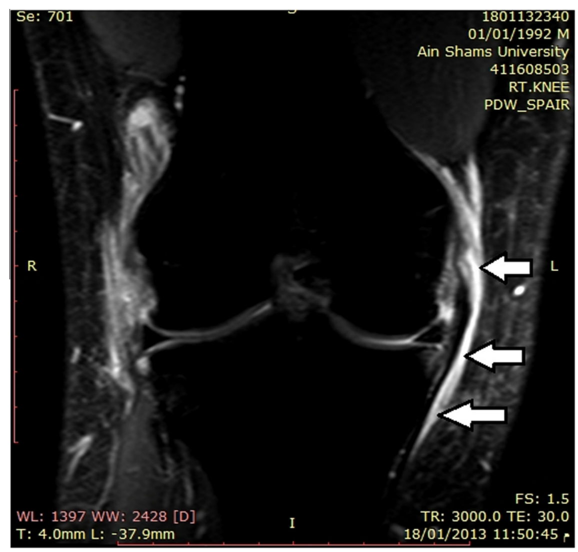

Fig. 22 Sagittal PDW (SPAIR) knee MR image, MCL is thickened with periligamentous edema, suggesting grade I sprain (arrows).

5.6. Case No. 6 (PCL sprain)

A 26 years old male patient presented with pain on the back of his right knee during deep flexion (squatting and kneeling).The condition started as direct trauma on his knee after tackling the ball while he was playing football (Figs. 18 and 19).

5.7. Case No. 7: (ACL tear, LCL sprain, MCL sprain and gastrocnimus muscle strain)

A 21 years old male presented with history of twisting trauma to his right knee of 4 months duration while he was playing

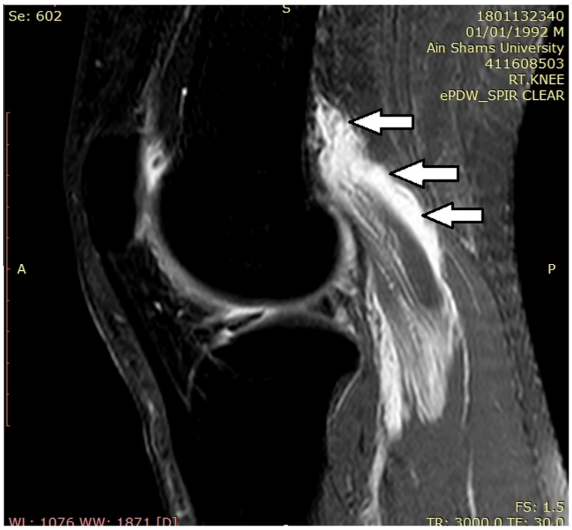

Fig. 23 Sagittal PDW (SPIR) knee MR image demonstrating abnormal bright signal noted in the lateral head of gastrocnemius muscle, suggesting grade I muscle strain (arrows).

Table 4 Distribution of patients according to knee injuries.

Injury	No.	%
ACL	15	60
PCL	2	8
Meniscus	10	40
Collateral ligaments	8	32
Bone	5	20
Muscular	2	8

Table 5 Distribution of patients according to type of injury.

Injury	No.	%
Isolated injury	7	28
Combined injuries	18	72
Total	25	100.0

Table 6 Distribution of patients according to leading sports.

Sport	No.	%
Football	24	80
Basketball	1	3.33
Jogging	3	10
Judo	1	3.33
Boxing	1	3.33
Total	30	100.0

Football, now the patient is presenting with pain on kneeling and knee flexion (Figs. 20–23).

Table 7 The validity of the knee MRI.

Validity	%
Sensitivity	92
Specificity	60
PPV	92
NPV	60
Accuracy	76

(PPV = positive predictive value, NPV = negative predictive value).

Table 8 Sensitivity and specificity of MRI for knee injuries.

Injury	Sensitivity (%)	Specificity (%)
ACL	86.6	90
PCL	100	100
Meniscus	80	85
Collateral ligaments	85	90

Conflict of interest

The authors should state that there were no conflicts of interests.

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